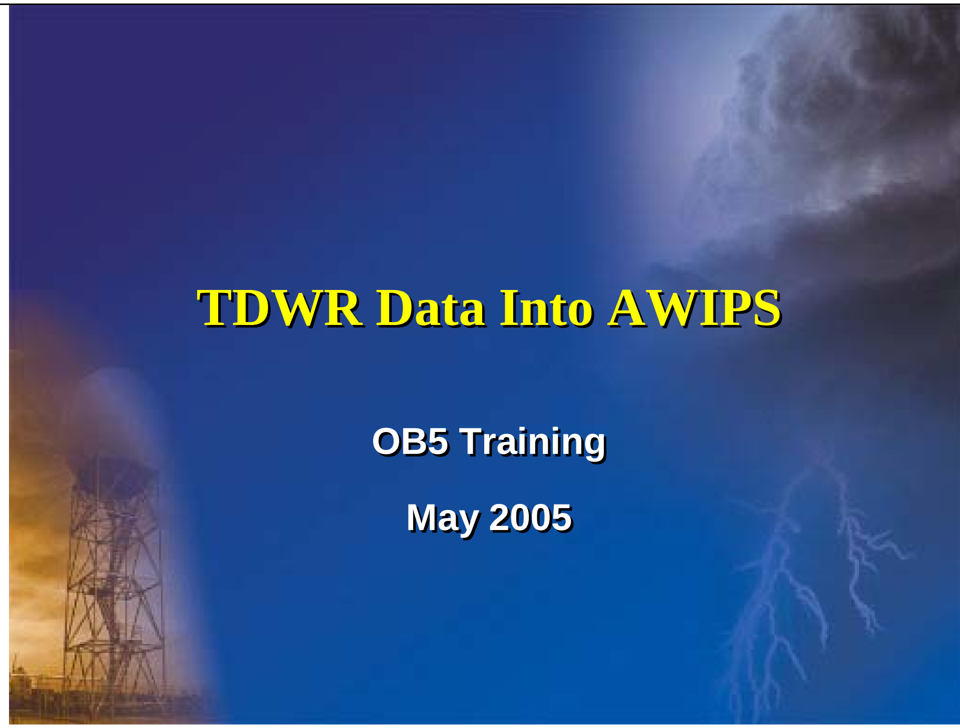


TDWR_Data_Into_AWIPS

Presentation Details:
Slides: 38
Duration: 00:22:57
Filename: C:\DATA\TDWR_DLOC05ver8.PPT

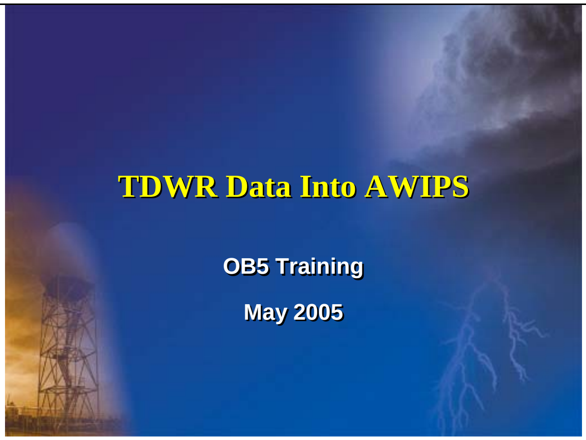
Presenter Details:
Name: John Ferree
Title: Instructor
Email: John.T.Ferree@wdtb.noaa.gov
Bio: I've been training at WDTB (formerly OTB) since 1993. Prior to that I worked at the Aviation Weather Center (AWC then called NAWAU). I've also worked at the CWSU in Olathe, Kansas, and the Forecast Offices in Reno, Nevada and Little Rock, AR.

Slide 1

TDWR Data Into AWIPS

Duration: 00:00:45

Advance mode: Auto



Notes:

Hi, My name is John Ferree, and I work for the Warning Decision Training Branch. This presentation is on an exciting new data set available to a few offices – Terminal Doppler Weather Radar (TDWR) Data. Luckily, our training branch office is in Norman, Oklahoma where both the National Severe Storms Lab and the Norman Forecast Office have had access to TDWR data for a few years now. So in addition to talking with the managers and developers on this project, I've been discussing the operational use of the data with some of the forecasters. My goal for this session is to not only describe the TDWR, but to help you use this new data **in your job.** This training module is about 25 minutes long.

Slide 2

Overview

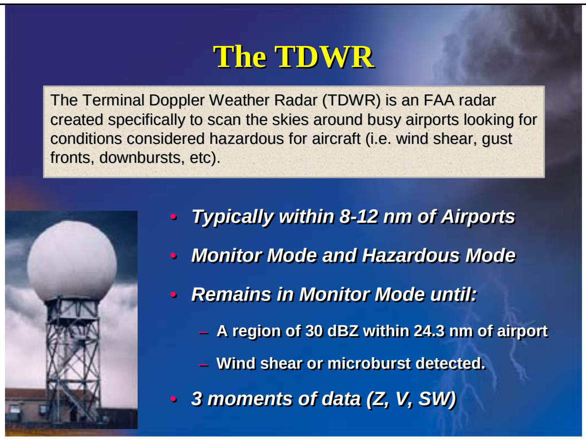
Duration: 00:00:20

Advance mode: Auto

Notes:

This presentation will begin by describing the Terminal Doppler Weather Radar itself, and how it compares to the WSR-88D. Then we will explore some of the strengths and limitations of the data, and how we might use the data in operations. At the end, we will discuss the planned evolution of TDWR data.

Slide 3
The TDWR
Duration: 00:01:34
Advance mode: Auto



Notes:

The TDWR was designed by the FAA to look for low altitude phenomena such as wind shifts over the runways, wind shear along the immediate approach and departure corridors, and downbursts. Therefore these radars are typically located close to major airports, and the scanning strategy is optimized to sample the atmosphere over its associated airport.

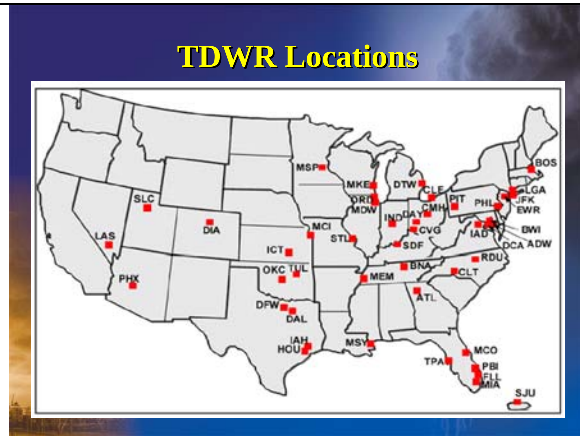
Similar to the WSR-88D, the TDWR employs a clear air-like scanning strategy (called 'monitor mode'). Precipitation-like mode is called 'hazardous mode'. The TDWR remains in monitor mode until one of the two following conditions are recognized:

- A region of 30 dBZ echoes must be located within 24.3 nm from its associated airport with a nominal areal extent of 1.3 nm and be at least 1.3 nm AGL, or
- Wind shear or a microburst has been detected

This is a departure from WSR-88D operations. The 88D can switch from clear air mode to precipitation mode if the areal coverage of precipitation exceeds an adaptable parameter anywhere on the scope. The TDWR's decision area of influence is tied directly to its associated airport. This means that a significant squall line may be occurring within the short range (say 40 nm), but unless the activity was located within the constraints listed above, the system could stay in monitor mode.

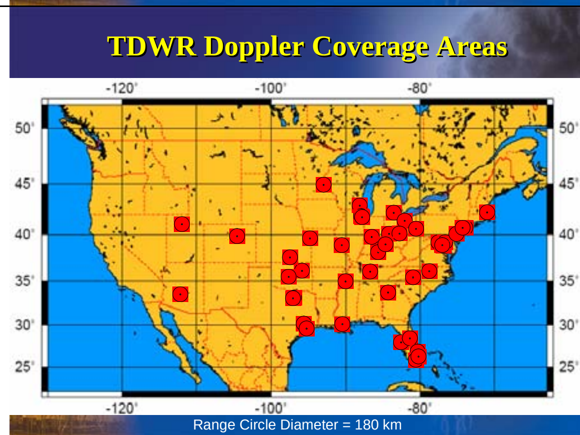
An explanation of scan strategies will be discussed in later slides.

Slide 4
TDWR Locations
Duration: 00:00:17
Advance mode: Auto



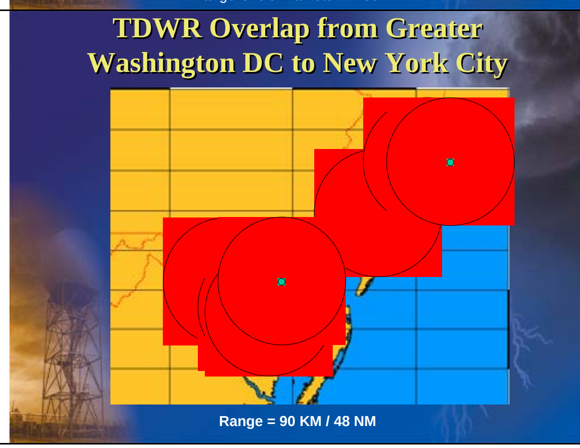
Notes:
There are 45 commissioned TDWRs in the CONUS and Puerto Rico. There are also two training radars (not shown on this map). The majority of TDWRs are located over the eastern half of the country where wet microbursts are more common.

Slide 5
TDWR Doppler Coverage Areas
Duration: 00:00:28
Advance mode: Auto



Notes:
The Doppler coverage area of the TDWR extends for a radius of 90 km. This slide shows the locations of the TDWRs as well as the short range coverage regions. Note the excellent Doppler coverage over the Ohio River Valley and the significant overlap of coverage along the urban northeast corridor, over the Gold Coast of southeast Florida, in metro Chicago, Dallas/Fort Worth, and Houston.

Slide 6
TDWR Overlap from Greater Washington DC to New York City
Duration: 00:00:24
Advance mode: Auto



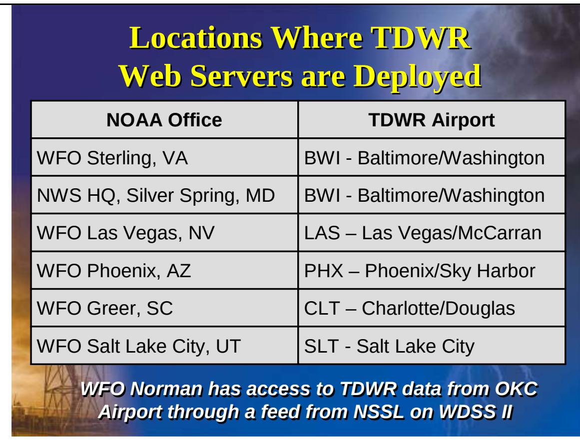
Notes:
This slide shows a close-up of the placement of TDWRs along the urban corridor from metro Washington to New York City. Note the extensive Doppler overlap over the Washington DC region and metro NYC. This same area has four WSR-88Ds (Sterling, Dover, Mt Holly, Brookhaven) that could be used for multiple Doppler analysis.

Slide 7

Locations Where TDWR Web Servers are Deployed

Duration: 00:00:33

Advance mode: Auto



Notes:

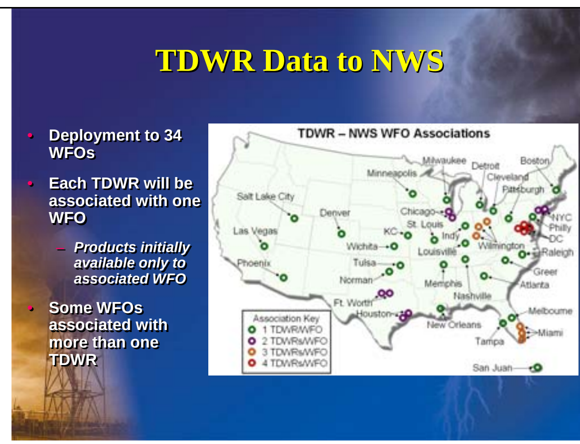
An intermediate deployment activity included the creation of a PC -based Web Server to allow for forecasters and researchers to study TDWR data before full Supplemental Product Generator (SPG) deployment. The list of 6 locations host Web Servers and have dedicated T1 communications with a TDWR (note: Sterling access data from NWS HQ).

Slide 8

TDWR Data to NWS

Duration: 00:00:43

Advance mode: Auto

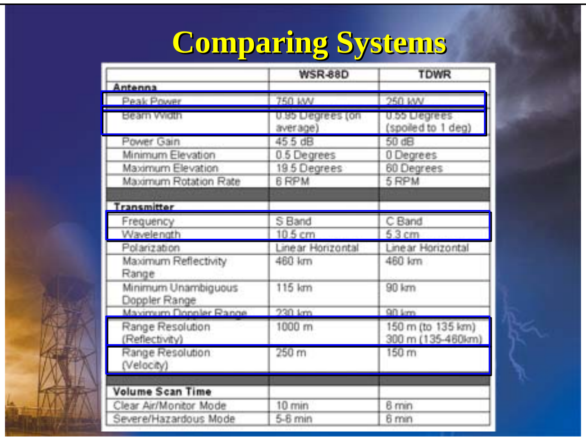


Notes:

With TDWRs assigned to specific airports, there are many situations where more than one TDWR is located within a WFOs county warning area (CWA). For example, there are four TDWRs within the CWA of WFO Sterling (LWX). Both WFO Miami and Wilmington (Ohio) have three TDWRs in their CWA.

Initially, AWIPS compliant radar products will be available only to the WFO that hosts the SPG. Eventually, these data will be made available to neighboring sites.

Slide 9
Comparing Systems
Duration: 00:01:13
Advance mode: Auto



	WSR-88D	TDWR
Antenna		
Peak Power	750 kW	250 kW
Beam Width	0.95 Degrees (on average)	0.55 Degrees (spoiled to 1 deg)
Power Gain	45.5 dB	50 dB
Minimum Elevation	0.5 Degrees	0 Degrees
Maximum Elevation	19.5 Degrees	60 Degrees
Maximum Rotation Rate	6 RPM	5 RPM
Transmitter		
Frequency	S Band	C Band
Wavelength	10.5 cm	5.3 cm
Polarization	Linear Horizontal	Linear Horizontal
Maximum Reflectivity Range	460 km	460 km
Minimum Unambiguous Doppler Range	115 km	90 km
Maximum Doppler Range	230 km	90 km
Range Resolution (Reflectivity)	1000 m	150 m (to 135 km) 300 m (135-460km)
Range Resolution (Velocity)	250 m	150 m
Volume Scan Time		
Clear Air/Monitor Mode	10 min	6 min
Severe/Hazardous Mode	5-6 min	6 min

Notes:

There are many similarities between the WSR-88D and the TDWR. Both use parabolic dishes and scanning strategies that create atmospheric volumes. Both use different pulse repetition frequency (PRF) scans for range and velocity mitigation. Both use linear horizontal polarization.

The obvious differences lie in wavelength, data resolution and scanning strategies. The TDWR was to have been an S band radar – but there was no available spectrum in this range when the system was designed. Hence, the standard attenuation issues are present with C band systems. The 88D also emits three times the power.

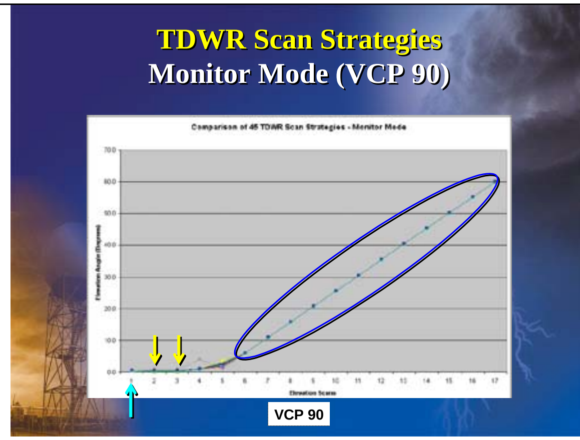
The TDWR has an angular beamwidth of 0.55 degrees. However, due to processing and communications limitations in the original technology (late 80s), the radials are spoiled to 1 degree in angular width when they leave their RPG. The TDWR radar data acquisition system is undergoing upgrades which may allow the higher resolution beam to be transmitted in the not too distant future.

The range resolution of all moments in the TDWR is 150 m. On the long range scan (once per volume), the resolution is reduced to 300 m beyond 135 km. Due to array size limitations in the WSR-88D RPG, **reflectivity resolutions are reduced to 300 m for short range products (90 km) and 600 m for long range**. Doppler moments (both velocity and spectrum width) remain at 150 m.

Long range scans are truncated at 276 km (149 nm) due to RPG array limitations.

Slide 10

TDWR Scan Strategies
Monitor Mode (VCP 90)
Duration: 00:00:56
Advance mode: Auto



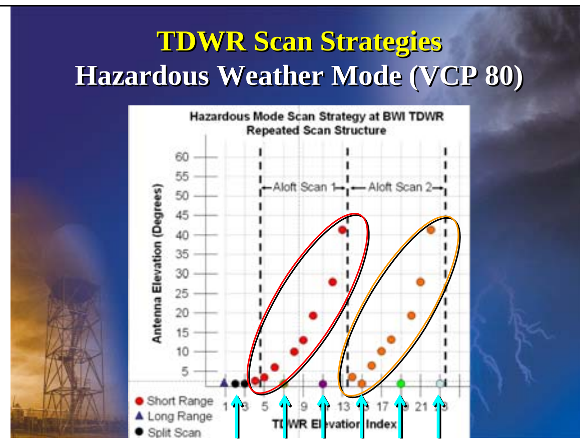
Notes:

VCP 90 is the TDWR monitor mode (clear air). VCP 90 consists of 17 scans in about 6 minutes. The first cut is always a low PRF, long range scan (276 km). All remaining scans are short range (90 km). There is a small variation in the elevation angles of the lower scans, but all scans above 5 degrees are the same in all systems.

Cuts 2 and 3 employ a “split cut” strategy. Cut 2 contains no dealiased Doppler data. Cut 3 (at the same elevation as cut 2) is the first cut to contain dealiased Doppler velocity data. The first three cuts are used to initialize wind field models and range and velocity unfolding algorithms.

Slide 11

TDWR Scan Strategies
Hazardous Weather Mode (VCP 80)
Duration: 00:00:60
Advance mode: Auto

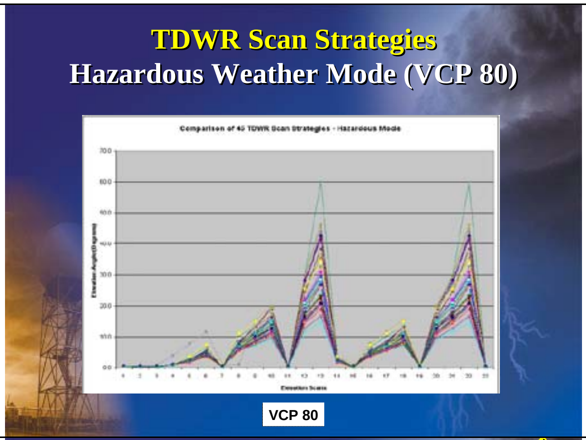


Notes:

VCP 80 is hazardous mode (precipitation mode) in the TDWR. This strategy is much more complex than what is employed in the 88D. Some key points include:

- The first scan is always a low PRF, long range (276 km) scan.
- Cuts 2 and 3 are the short range split cut scans used to collect information for unfolding and clutter mitigation algorithms. The first cut with dealiased Doppler data is cut 3.
- There are two ‘sub volumes’ or ‘aloft scans’ contained in each full volume (as denoted by the use of red and orange).
- About every minute (every 4th scan), the TDWR provides a short range low elevation scan (at the same elevation as cuts 2 and 3). The different colors used on the graphic are meant to show that different volume scan times are applied to each low elevation scan so that AWIPS can create 1 minute loop updates.

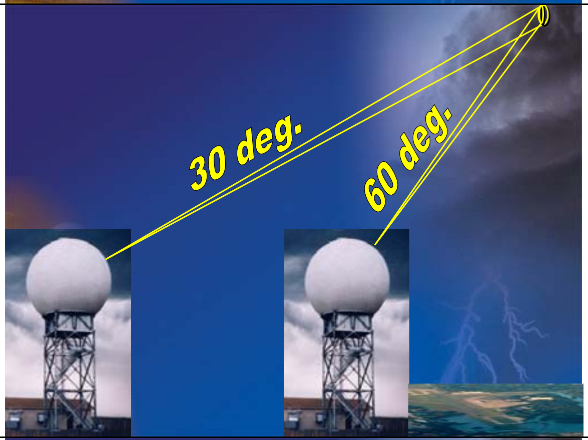
Slide 12
TDWR Scan Strategies
Hazardous Weather Mode (VCP 80)
Duration: 00:00:30
Advance mode: Auto



Notes:

This graphic shows how varied the hazardous mode elevation angles are across the 45 unit TDWR network. Each color in the graphic represents an individual TDWR. While the overall strategies are the same, individual cuts can differ between radars by 45 degrees. The reason for the varied elevation angles involves the relative placement of the TDWR to its associated airport and surrounding terrain.

Slide 13
Elevation angles optimized for airport
Duration: 00:00:25
Advance mode: Auto

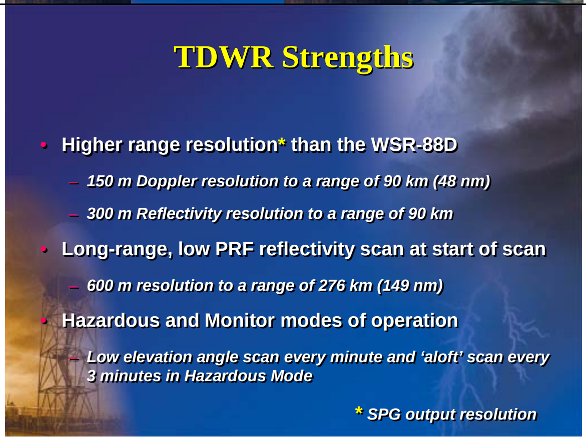


Notes:

As an example, an airport is depicted at the lower right and a TDWR is depicted at the far left. To get to storm top the radar must scan to 30 degrees.

If the radar is much closer to the airport, then the radar must scan to 60 degrees to get to the same storm top altitude.

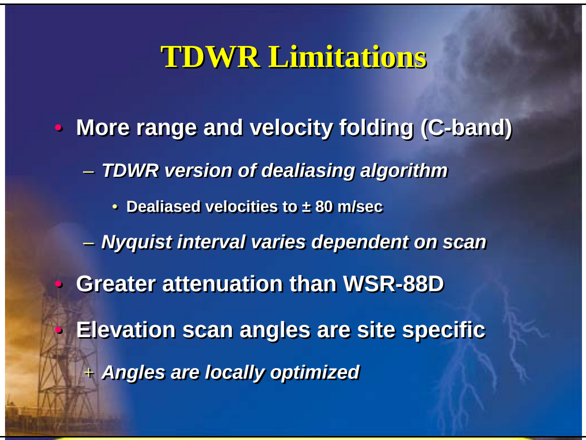
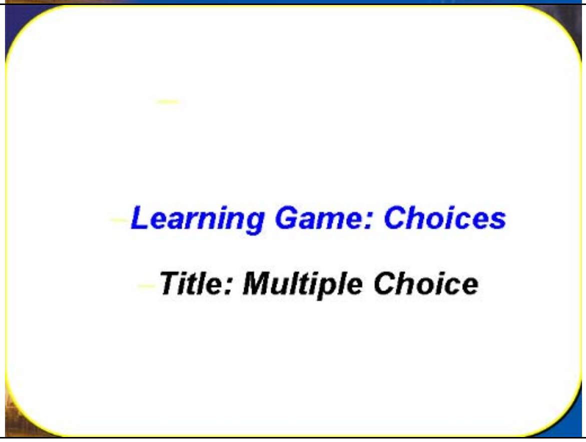
Slide 14
TDWR Strengths
Duration: 00:01:07
Advance mode: Auto



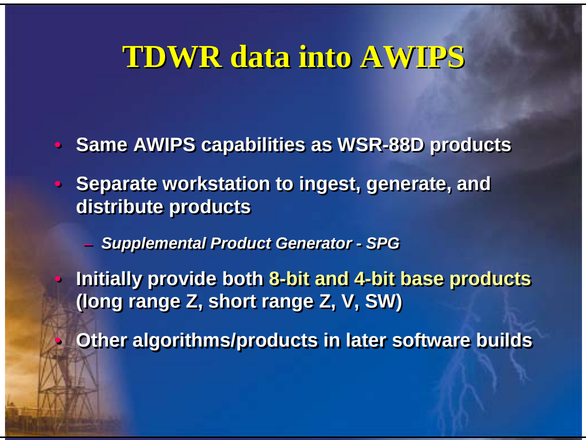
Notes:

The actual range and resolution of the TDWR scans is:
Short range (all moments): 150 m to 90 km
Long range (only reflectivity): 150 m to 135 km and 300 m from 135 km to 460 km

Because of limitations within the SPG (a modified RPG), products will be generated with the following resolutions:
Short Range Doppler (velocity and spectrum width): 150 m to 90 km (48 nm)
Short Range Reflectivity: 300 m to 90 km (48

		nm) Long Range Reflectivity: 600 m to 276 km (149 nm) Recall that in Hazardous mode the low elevation scan is every minute and aloft scan every three minutes.
Slide 15 **TDWR Limitations** Duration: 00:00:25 Advance mode: Auto		**Notes:** This is an important slide, as the TDWR has some significant limitations that must be understood by the operator in order to best use this data. These limitations are typical of using a C-band system rather than S-band. Later in this presentation we will demonstrate the impacts of these limitations within a case study.
Slide16 **Multiple Choice** Interaction type: Choices Passing score: 100 Instructions: None Custom Message: None		**Questions:** 1. Similarities between the TDWR and WSR-88D include: 1) wavelength and data resolution. 2) parabolic dish and linear horizontal polarization. (Correct) 3) beamwidth and range resolution. 4) scanning strategies and emitted power.

Slide 17
TDWR data into AWIPS
Duration: 00:00:42
Advance mode: Auto



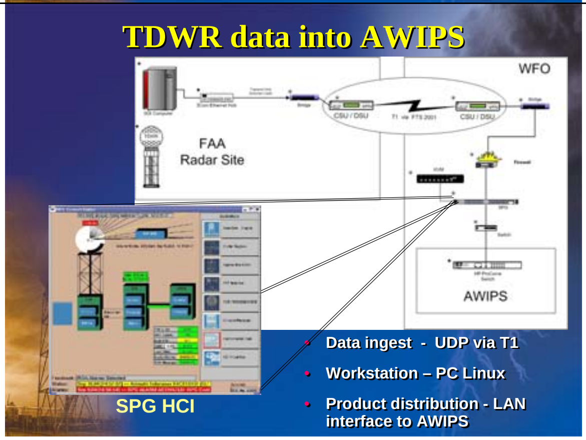
Notes:

Having the data in AWIPS allows the operator to have the same capabilities (zooming, looping, overlays, sampling) as with WSR-88D data

Initially, the SPG will only produce 8-bit and 4-bit products.

Note: Only a 4-bit spectrum width product will be generated

Slide 18
TDWR data into AWIPS
Duration: 00:00:51
Advance mode: Auto

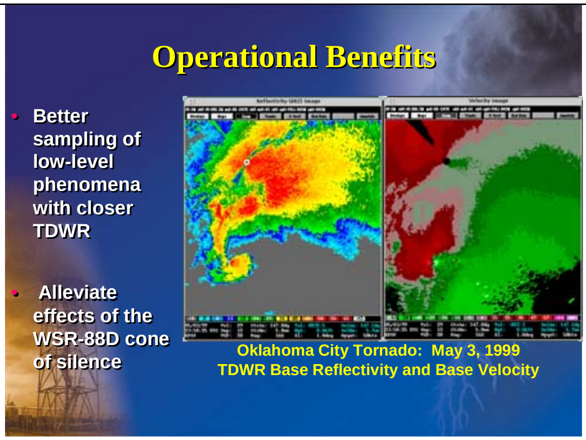


Notes:

This is a simplified diagram of how the data flows into AWIPS. Most of the equipment at the top of the diagram resides at the FAA Radar Site. The data flows over a T1 line to the Supplemental Product Generator (SPG) that has a Human Computer Interface (HCI) similar to the RPG. Note a lot of buttons are grayed out **since you have no control of the RDA.** The data flows to AWIPS via a LAN connection.

Note: On the SPG both Monitor and Hazardous Modes are considered Precipitation Modes.

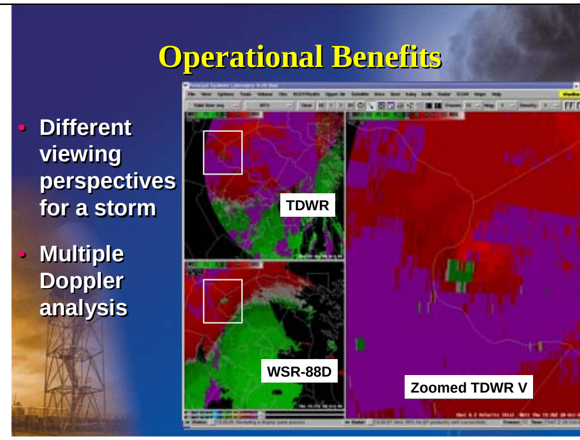
Slide 19
Operational Benefits
Duration: 00:00:43
Advance mode: Auto



Notes:

Now we will begin looking at TDWR data. These images are from the TDWR associated with the Oklahoma City Will Rogers Airport. Recall that forecasters at the Norman WFO view this data on a non-AWIPS workstation. So these screen captures will look a little diffferent from what you will be seeing on AWIPS.

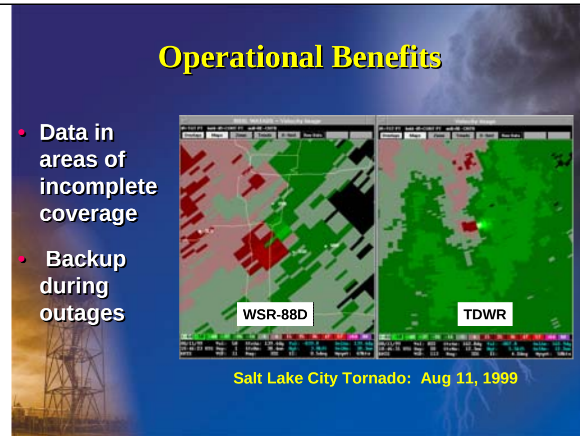
The most obvious benefit of having TDWR data is when you are looking for low-level phenomena such as hook echoes, TVS, divergent velocities from downburst, and gust fronts.

		In many cases, the TDWR data will provide radar data inside the WSR-88D cone of silence.
Slide 20 **Operational Benefits** Duration: 00:00:53 Advance mode: Auto	 	**Notes:** These images are from the TDWR associated with th Baltimore Airport, and displayed on an AWIPS workstation. In this example, the WSR-88D is actually closer to the highlighted phenomena, and therefore samples the mesocyclone better than the TDWR. The benefit of having the TDWR data is having a different viewing angle which can assist in determining actual wind direction. In the future, post processing of the data may yield estimates of wind direction and speed in some areas. While we are on this slide, we should note that AWIPS OB5 will allow the TDWR data to be manipulated (zoomed, enhanced, looped) similar to the WSR-88D. At the time of this recording, there were some outstanding issues with all-tilts and 4-panel displays of TDWR data.

Slide 21

Operational Benefits

Duration: 00:00:26
Advance mode: Auto



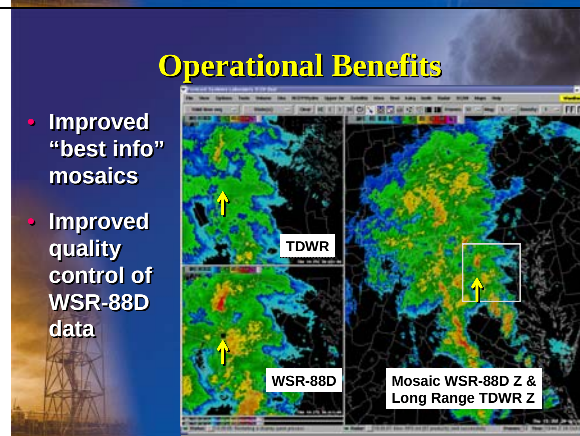
Notes:

In this example, the Salt Lake City WSR-88D is at a greater distance to metropolitan Salt Lake City than the TDWR. The WSR-88D also is located at a higher altitude. Therefore the WSR-88D 0.5 degree beam is higher above the city than the TDWR 0.5 degree elevation beam.

Slide 22

Operational Benefits

Duration: 00:00:25
Advance mode: Auto



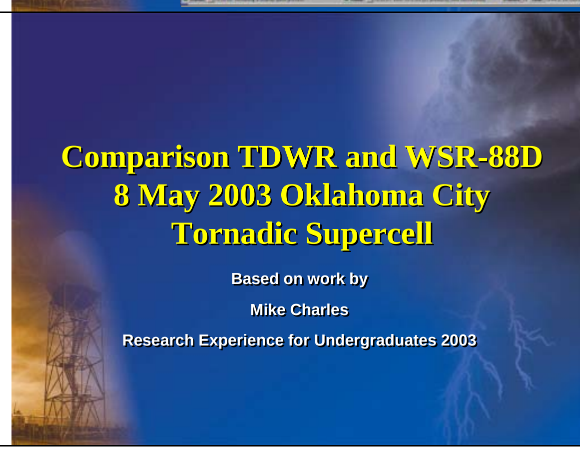
Notes:

Note that the area highlighted is near the WSR-88D, so the mosaic includes mostly WSR-88D data. The exception is the hole in the data at the location of the WSR-88D due to the cone of silence is not seen in the mosaic do to the introduction of the TDWR data.

Slide 23

Comparison TDWR and WSR-88D 8 May 2003 Oklahoma City Tornadic Supercell

Duration: 00:00:17
Advance mode: Auto



Notes:

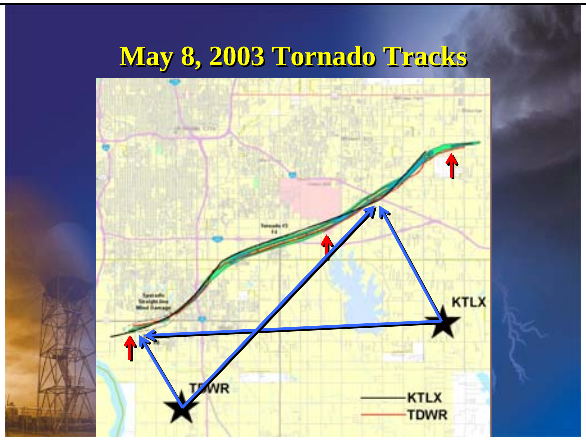
Thanks to Mike Charles, who was a student in the Research Experience for Undergraduates during the summer of 2003 for this next set of slide. Also, to Dave Andra, the SOO at the Norman Forecast Office, for providing us with much of this operational information.

Slide 24

May 8, 2003 Tornado Tracks

Duration: 00:00:38

Advance mode: Auto



Notes:

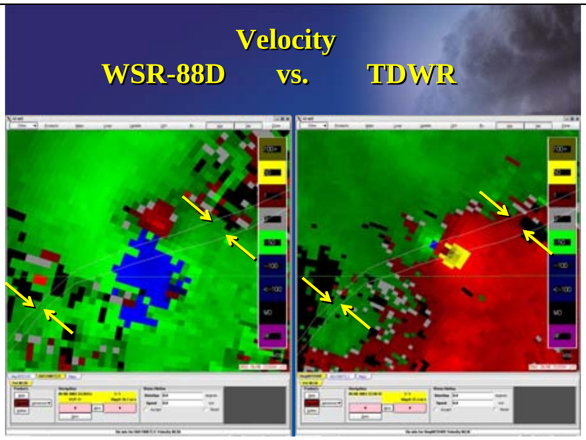
This is a map of Oklahoma City, Moore, Del City and Midwest City. The colored area which we will take a closer look at later is the track of an F4 tornado that started in Western portions of Moore Oklahoma, tracked just south of Tinker AFB (pink color) and through Southeastern portions of Midwest City. We will look at data from two radars. The OKC TDWR which as you can see is closer to the initial touchdown than the Twin Lakes (KTLX) WSR-88D is closer to the tornado during the later part of the track.

Slide 25

Velocity WSR-88D vs. TDWR

Duration: 00:00:57

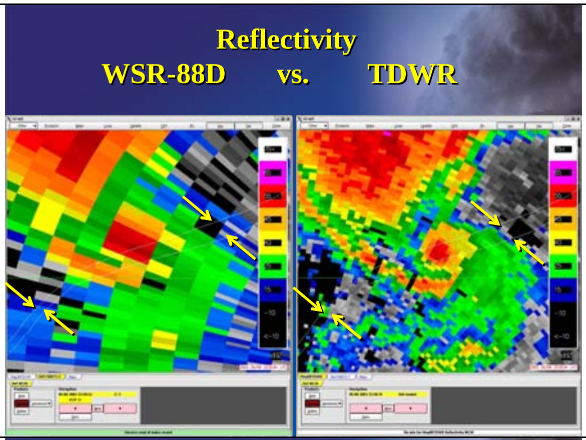
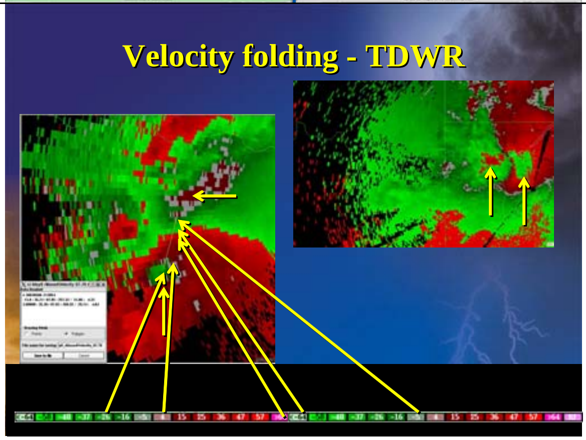
Advance mode: Auto

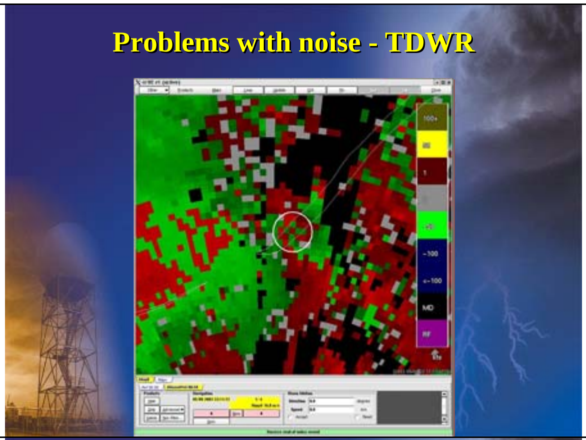
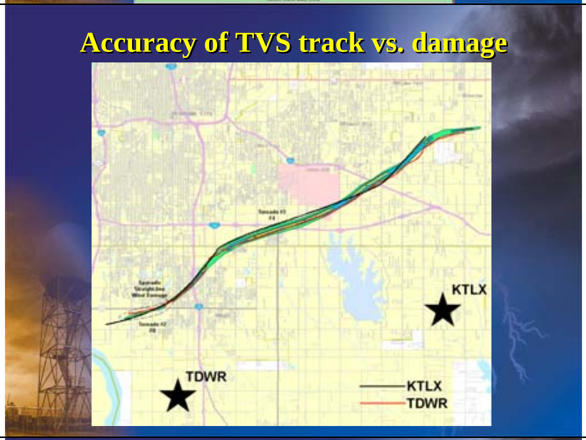
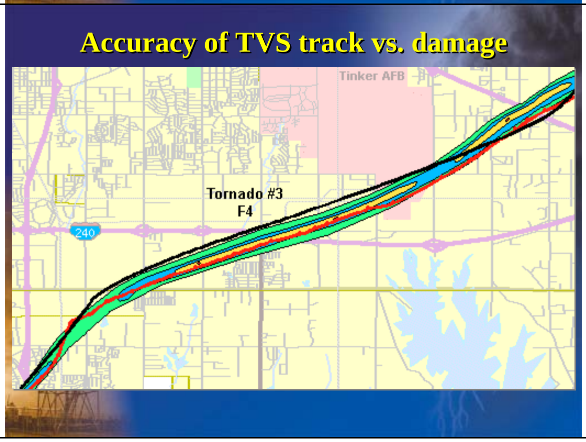


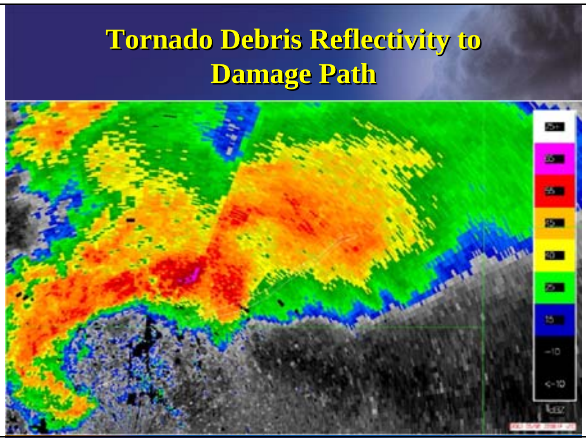
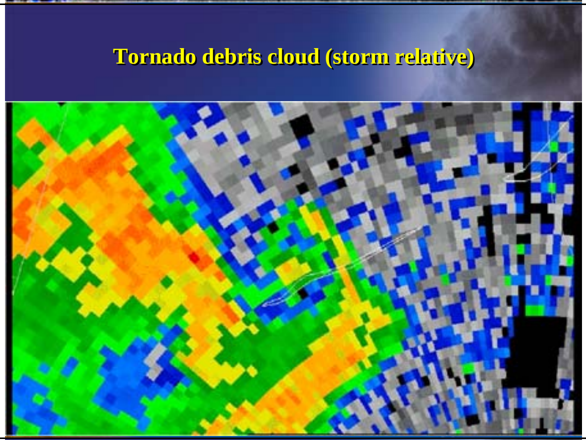
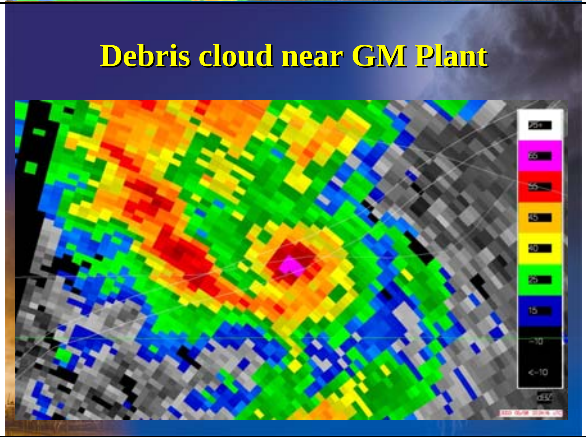
Notes:

These two velocity images are in identical areas within 35 seconds of each other. The white lines in the background (between yellow arrows) bound the damage swath of the tornado. At this time the tornado was approximately equidistant from the two radars.

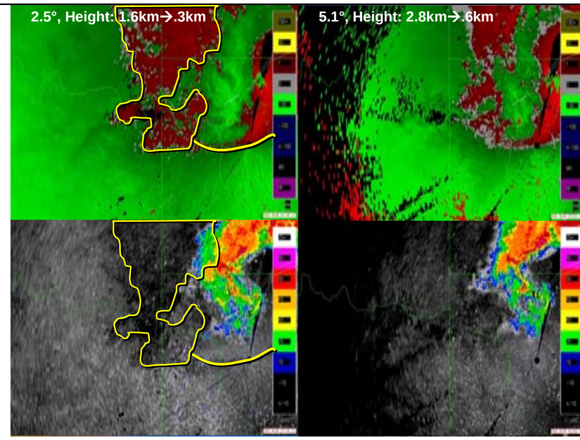
At this time the TVS signature was better located with respect to the tornado on the TDWR that WSR-88D. The TVS from the WSR-88D was displaced slightly north of the damage. This is due to a combination of viewing angle and the difference in range resolution (150 meters for TDWR vs. 250 meters for the WSR-88D). Recall the difference in range resolution is even greater in reflectivity (150m for TDWR vs. 1000m for the WSR-88D).

Slide 26 **Reflectivity WSR-88D vs.TDWR** Duration: 00:00:15 Advance mode: Auto		**Notes:** Here are the reflectivity images from the same time period. The highly reflective “debris ball” is noticeable on both images, but the better resolution of the TDWR allows for much greater detail.
Slide 27 **Velocity folding - TDWR** Duration: 00:01:41 Advance mode: Auto		**Notes:** One of the limitations of the TDWR mentioned earlier is there is more velocity aliasing in the data when there are high velocities. Here are some extreme examples. On the large image on the left, the green inside the large red area is in an area that folded twice – folding from green inbound to red and back to green inbound. On the north side of the circulation the strongest actual outbound velocity is very weak. Similar areas of aliased velocities can be seen in the image on the upper right where strong inbound velocities fold over to red and strong outbound velocities fold over to green. As you can see this can become very confusing. These are extreme examples, and some improvement is expected in the future as better velocity dealiasing algorithms are developed. Nonetheless, watch for aliased velocities in high wind events.

Slide 28 **Problems with noise - TDWR** Duration: 00:00:08 Advance mode: Auto		**Notes:** Another example where strong winds produce a chaotic velocity pattern.
Slide 29 **Accuracy of TVS track vs. damage** Duration: 00:00:15 Advance mode: Auto		**Notes:** Back to this map. Mike Charles noted that the for this particular tornado the TVS on the TDWR more closely followed the actual tornado the TVS on the WSR-88D. Lets zoom in.
Slide 30 **Accuracy of TVS track vs. damage** Duration: 00:00:30 Advance mode: Auto		**Notes:** The light green is F0 and F1 damage, the light blue is F2 damage, and the yellow is F3 damage, with dots of red indicating areas of F4 damage. The black line is the track of the WSR-88D TVS, and the red line is the track of the TDWR TVS. For most of the track of this tornado, the TDWR TVS more closely located the actual damage.

Slide 31 **Tornado Debris Reflectivity to Damage Path** Duration: 00:00:33 Advance mode: Auto Flash movie: TDWR_TORground.swf Display : In Articulate player		**Notes:** A couple of limitations can be seen on this loop. You can easily note areas of attenuation behind higher reflectivity cores. Also you can see there are problems with the range unfolding logic. The long range scan is used to mask data on the short range scans. Note where the reflectivity abruptly skips to black, and at times within the black there is a misplaced echo from the second trip.
Slide 32 **Tornado debris cloud (storm relative)** Duration: 00:00:28 Advance mode: Auto Flash movie: TDWR_TORstorm.swf Display : In Articulate player		**Notes:** This loop follows the highly reflective 'debris ball'. Note how well it correlates with the tornado damage path between the two white lines.
Slide 33 **Debris cloud near GM Plant** Duration: 00:00:15 Advance mode: Auto		**Notes:** Here is one of the frames from the previous loop. This extremely high reflectivity occurred about the time the tornado hit a large General Motors plant. Automobile parts and pieces of sheet metal are highly reflective.

Slide 34
Clutter Suppression
Duration: 00:00:52
Advance mode: Auto



Notes:
Here is some TDWR data from the OKC TDWR during the development of the Tornado to the SW of Moore, OK. The track is depicted by the white lines on the right side of each panel.
As I animate through this loop you can see the value of the high resolution reflectivity so close to the radar. There is also good velocity data, but with some aliasing of the data. Can you see this? It will take some practice.

At the end of the loop, note the zero isodop in the 2.5 degree I'd

Note the zero isodop evident on the reflectivity product. The TDWR employees a lot of clutter filtering, and you often see a lowering of dBZ intensity.

Slide35
Choices
Interaction type: Choices
Passing score: 100
Instructions: None
Custom Message: None

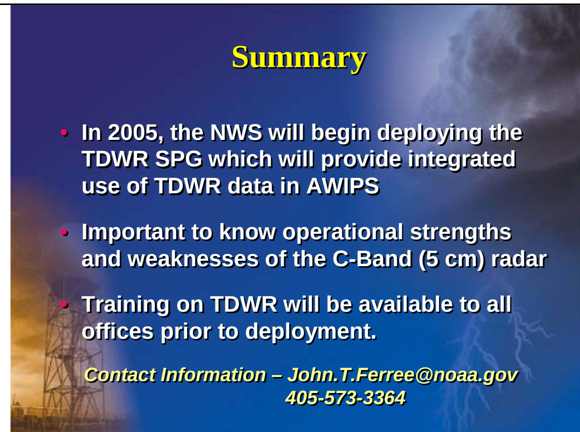
Questions:
1. Which of the following data anomalies do you see in TDWR data?
1) Reduced reflectivities in areas of zero velocities
2) Reduced reflectivities behind high reflectivity cores
3) Second trip echoes
4) Aliased velocities
5) All of the above (Correct)

Slide 36
NWS Future Plans
Duration: 00:00:36
Advance mode: Auto

Notes:

Future plans are to add some of the algorithms to the SPG to produce new TDWR products such as Composite Reflectivity, Vertically Integrated Liquid, Velocity Azimuth Wind Displays, Cell Tracking, Mesocyclone Detection, TVS Detection, and Precipitation Products. Also, planned are ways to distribute the data more widely, and perhaps develop multiple Doppler radar algorithms. Pilot projects are also in progress on other FAA radars such as the ASR-11 and ARSR-4.

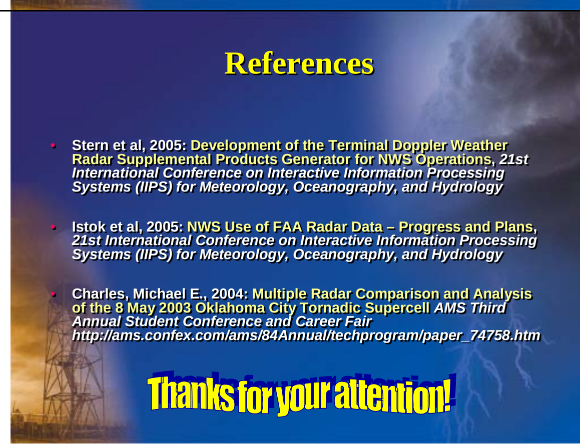
Slide 37
Summary
Duration: 00:00:22
Advance mode: Auto



Notes:

This program is in its initial stages and we will be relying on the forecasters at initial deployment site to provide us a better understanding of the operational strengths and limitations. This training will also need to expand and evolve. Please feel free to contact me by e-mail or telephone with comments or suggestions.

Slide 38
References
Duration: 00:00:30
Advance mode: Auto



Notes:

If you would like more information, here are the references I used for this presentation.
A special thanks to Mike Istok, Peter Pickard, and Brian Klein in NOAA's National Weather Service Office of Science and Technology, and to Andy Stern of Mitretek Corporation for there guidance and invaluable review.
Mike Charles and Dave Andra at the Norman Forecast Office also provided me with the slides in the last half of this presentation.